Muted Tropospheric Warming Since 1998: "Evidence of Absence" of a Human Effect on Global Climate?

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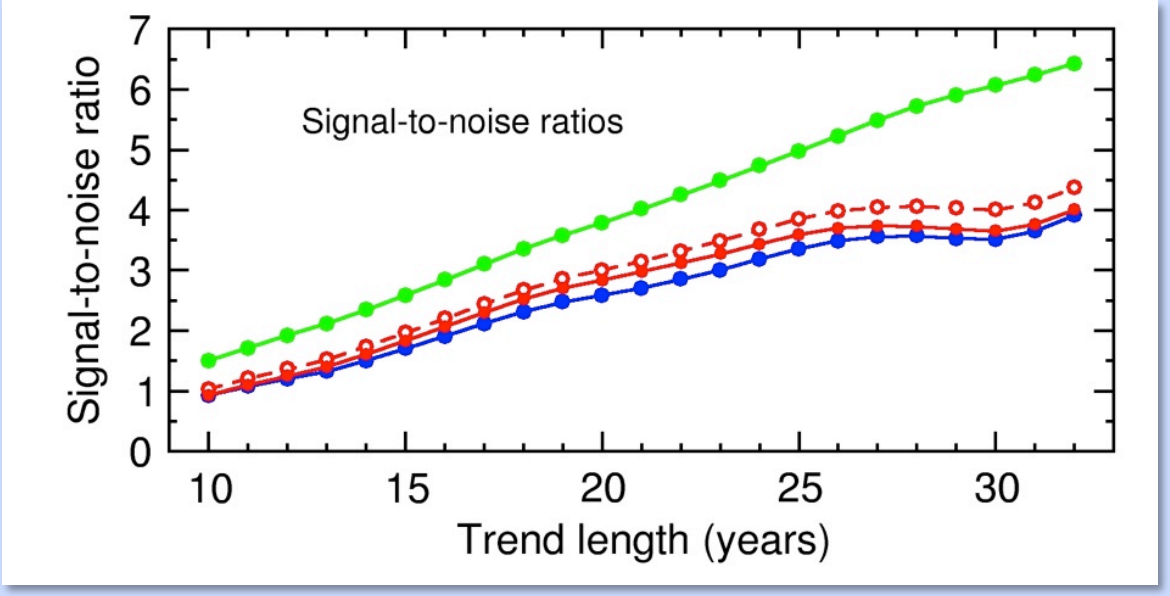
CERES Science Team Meeting, Lawrence Livermore National Laboratory, Livermore, CA

Oct. 5, 2011



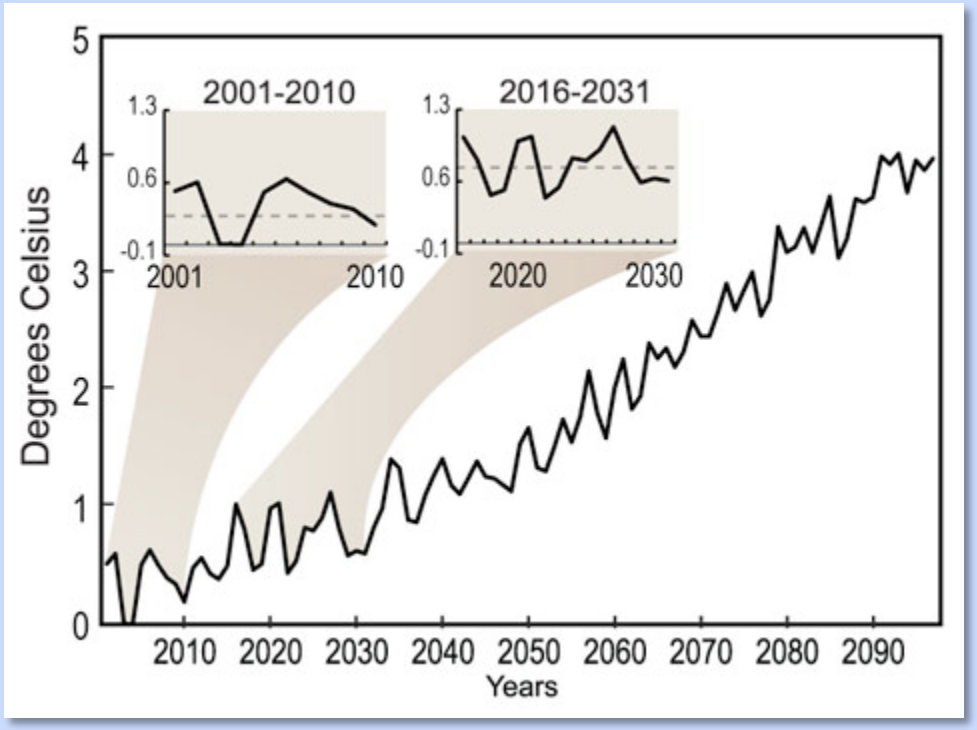
Fact or fiction? “Computer models can’t simulate the small warming observed over the last 10 years”

- “Over the past ten years there has been no statistically (sic) global warming. This is not at all what was predicted by the IPCC computer models”.*

*Professor Will Happer, “Climate Science in the Political Arena”

Testimony before U.S. House of Representatives Select Committee on Energy Independence and Global Warming, May 20, 2010

Previous relevant work by Easterling and Wehner (*GRL*, 2009)

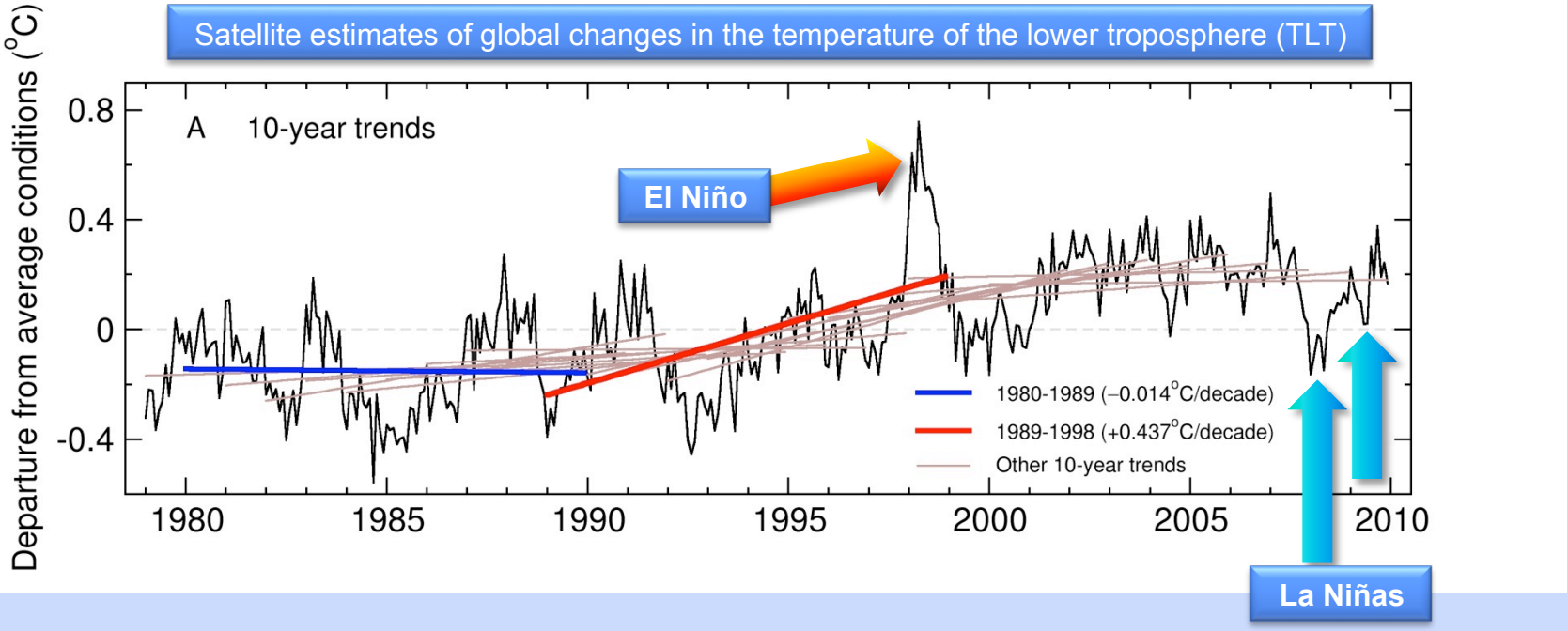


A climate simulation in a world facing "business as usual" increases in greenhouse gases still shows lots of periods with cool fluctuations

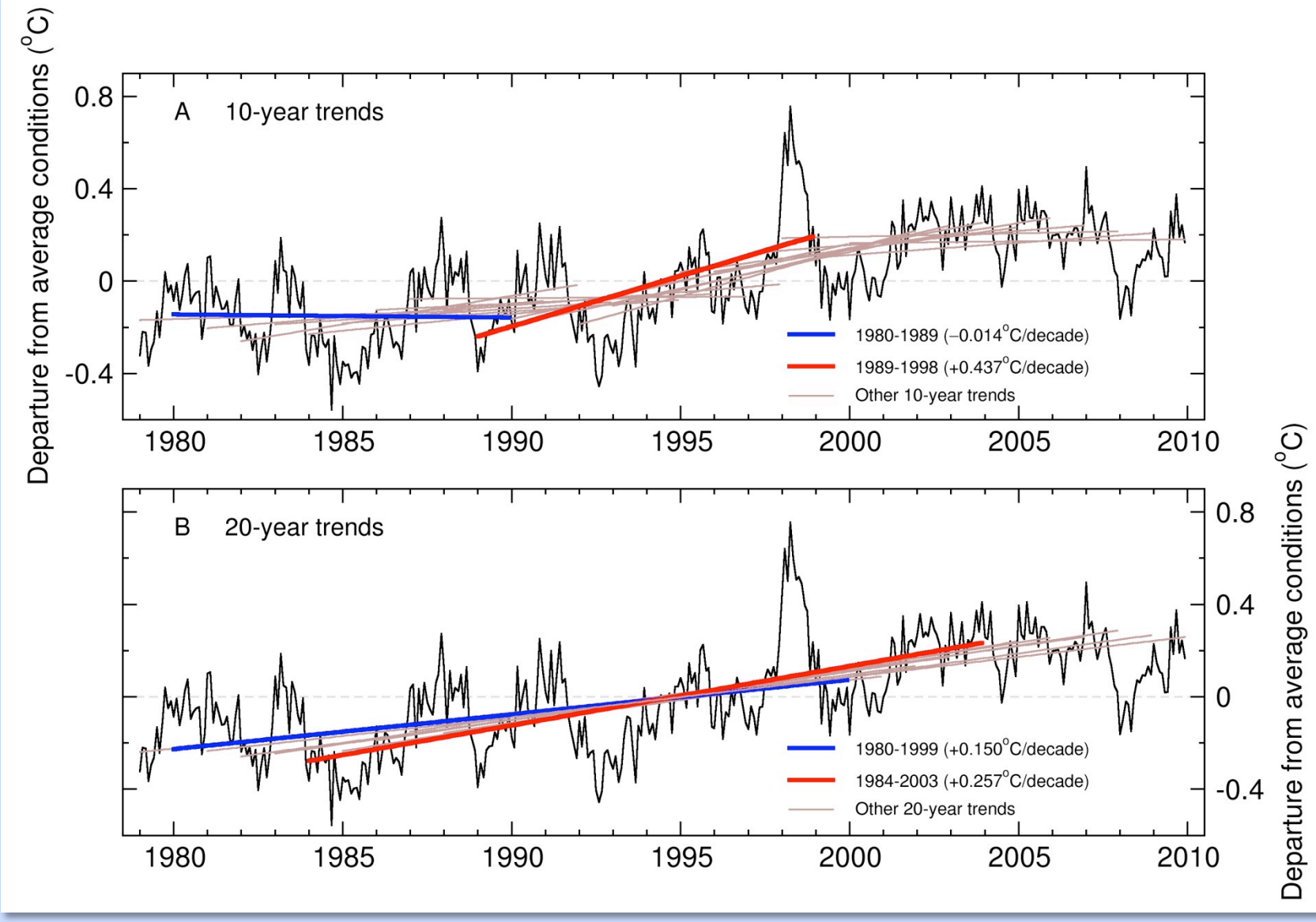
The fundamental issue here is one of signal-to-noise ratios (S/N)

- Signal: The climate response to human influences
- Noise: Purely natural changes in climate, both externally-forced (by changes in the Sun and volcanic dust) and internally-generated
- Identifying a human-caused climate change signal is a S/N problem
- The climate science community has studied this problem for 30+ years:
  - Hasselmann (1979); Madden and Ramanathan (1980); Wigley and Jones (1981); Bell (1982); Barnett and Schlesinger (1987); Wigley and Raper (1990); Karl *et al*. (1991); Santer *et al*. (1994, 1995, 1996); North *et al*. (1995); Hegerl *et al*. (1996, 1997); Tett *et al*. (1996); Stott *et al*. (2000); Easterling and Wehner (2009)

Ten-year trends are strongly influenced by interannual noise



Computing trends over longer periods of record reduces the influence of interannual noise



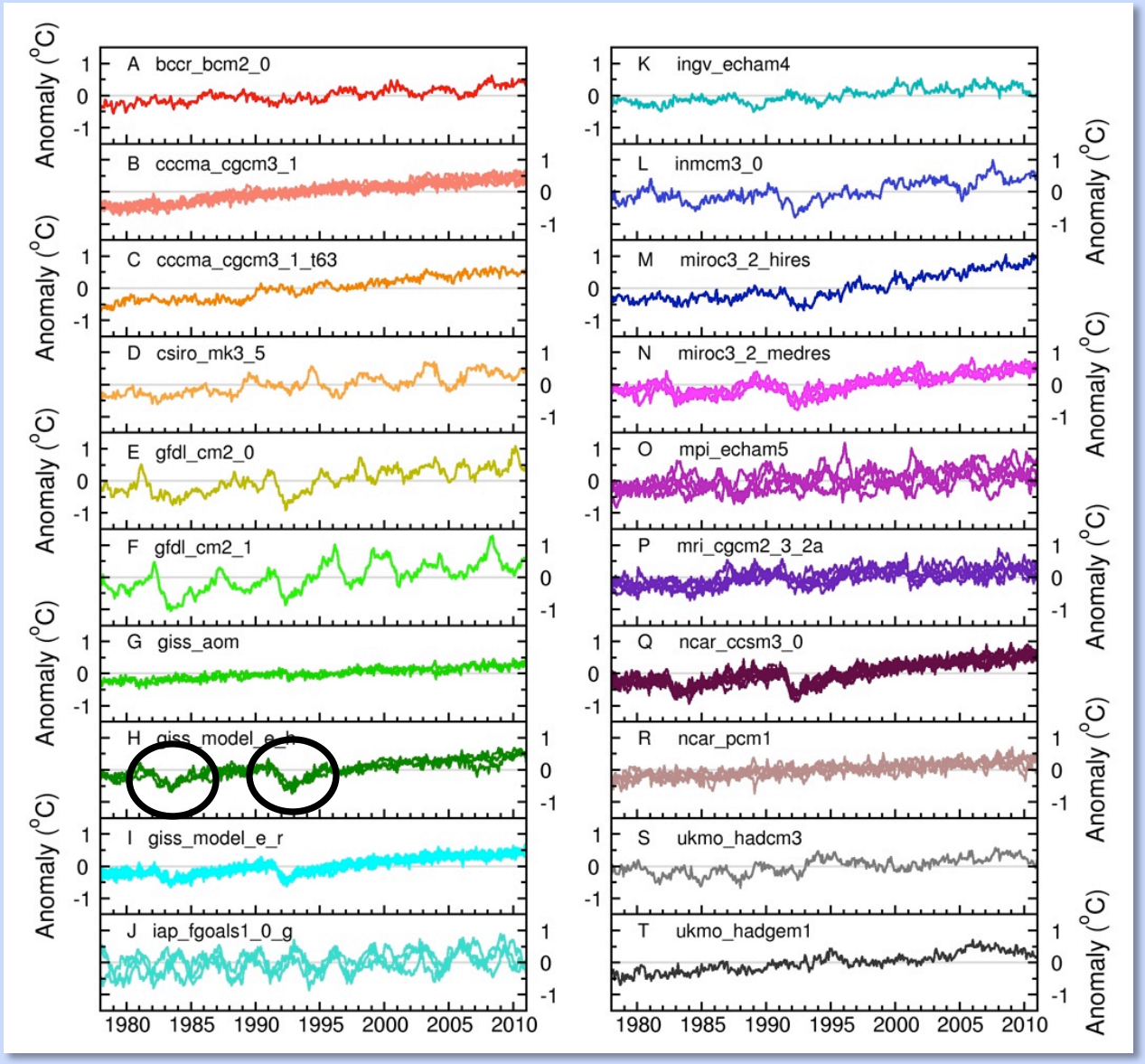
Scientific questions we would like to address

- Can current climate models simulate 10-year periods with little or no tropospheric warming, even under anthropogenic forcing?
- How do S/N ratios behave as a function of increasing timescale?
- For global-scale changes in lower tropospheric temperature, how many years of record are required in order to discriminate between an anthropogenically-forced warming signal and the noise of internally-generated variability?
- Are model-based estimates of tropospheric temperature variability systematically lower than observed on the multi-decadal timescales of most relevance for anthropogenic signal detection?

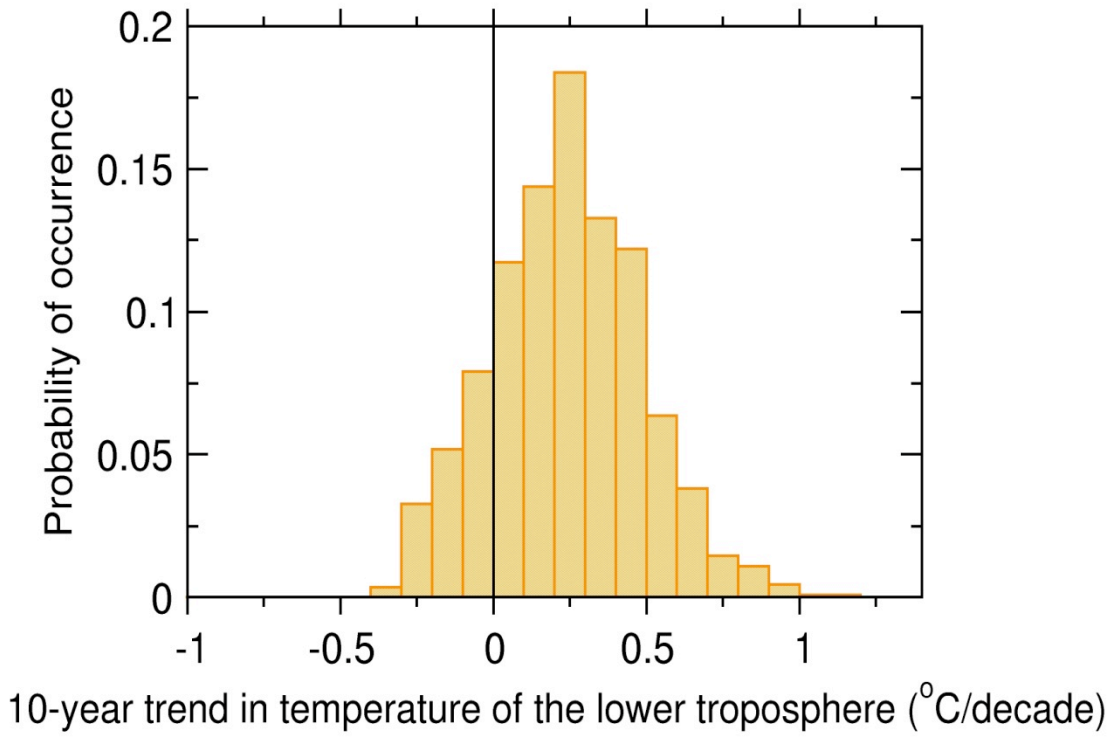
Processing of CMIP-3 data

- Calculated synthetic satellite temperatures using "extended" 20th century simulations performed with 20 different CMIP-3 models
- Extension of 20th century simulations is with SRES A1B runs
- In most cases, the "splice point" is in 1999 or 2000
- Enables comparison of modeled and observed trends compared over 1979 to 2010
- Also calculated synthetic satellite temperatures from CMIP-3 pre-industrial control runs
- All results are for global-mean lower tropospheric temperature (TLT)

CMIP-3 simulations of TLT changes over 1979 to 2010 in "spliced" 20CEN/SRES A1B simulations



Can computer models produce 10-year periods with little or no warming?*



*When run with human-caused changes in greenhouse gases, aerosols, *etc.*

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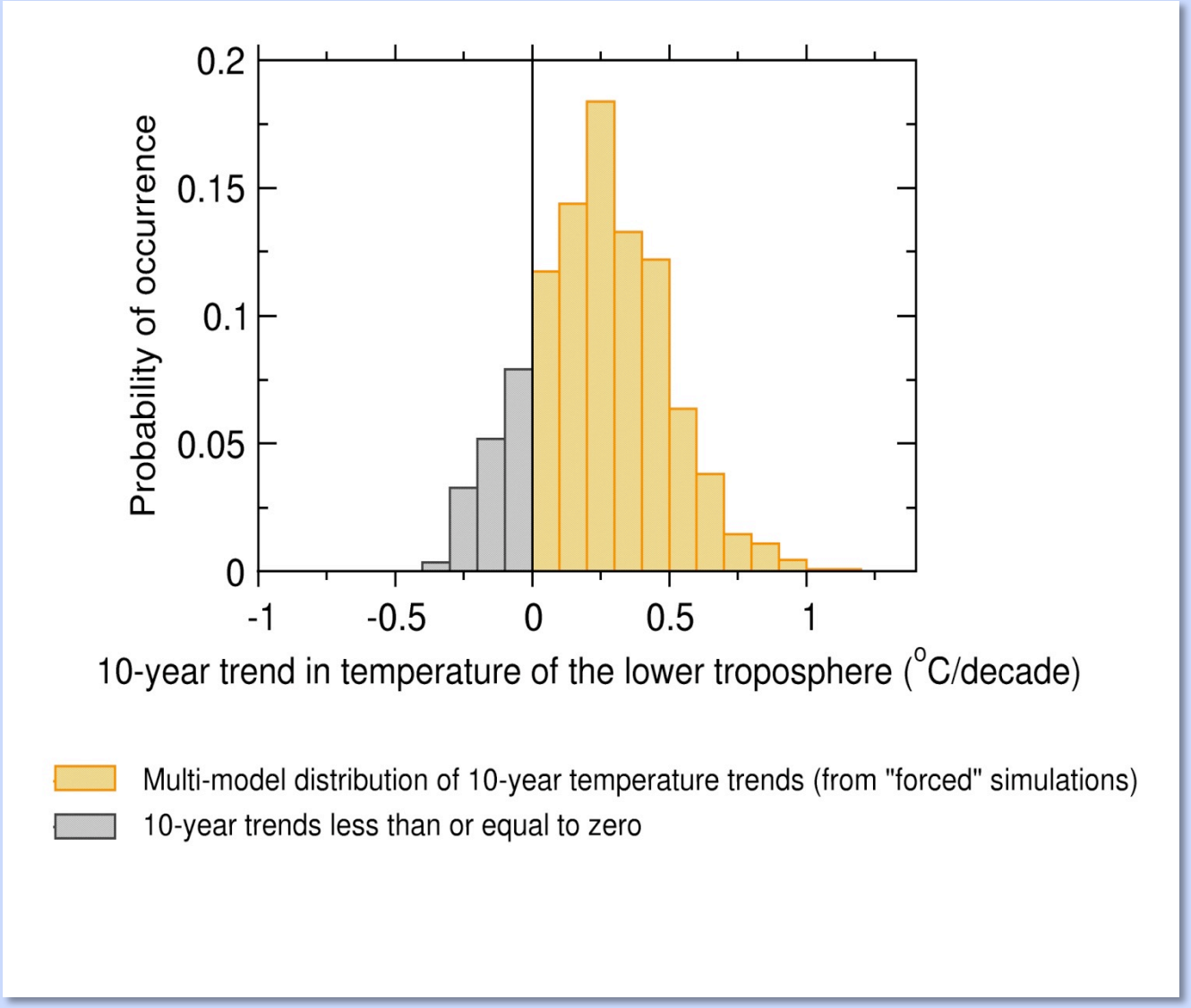

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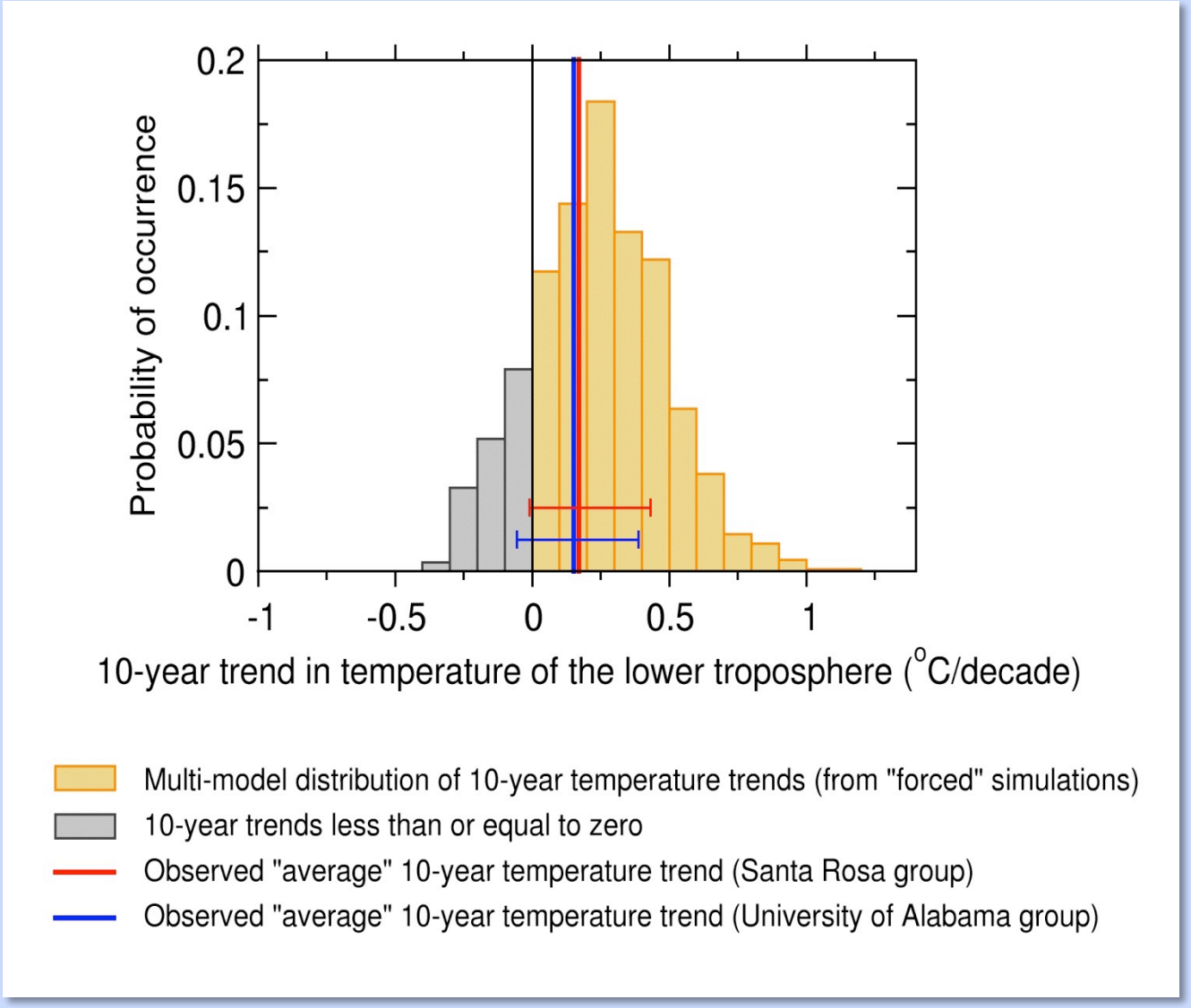
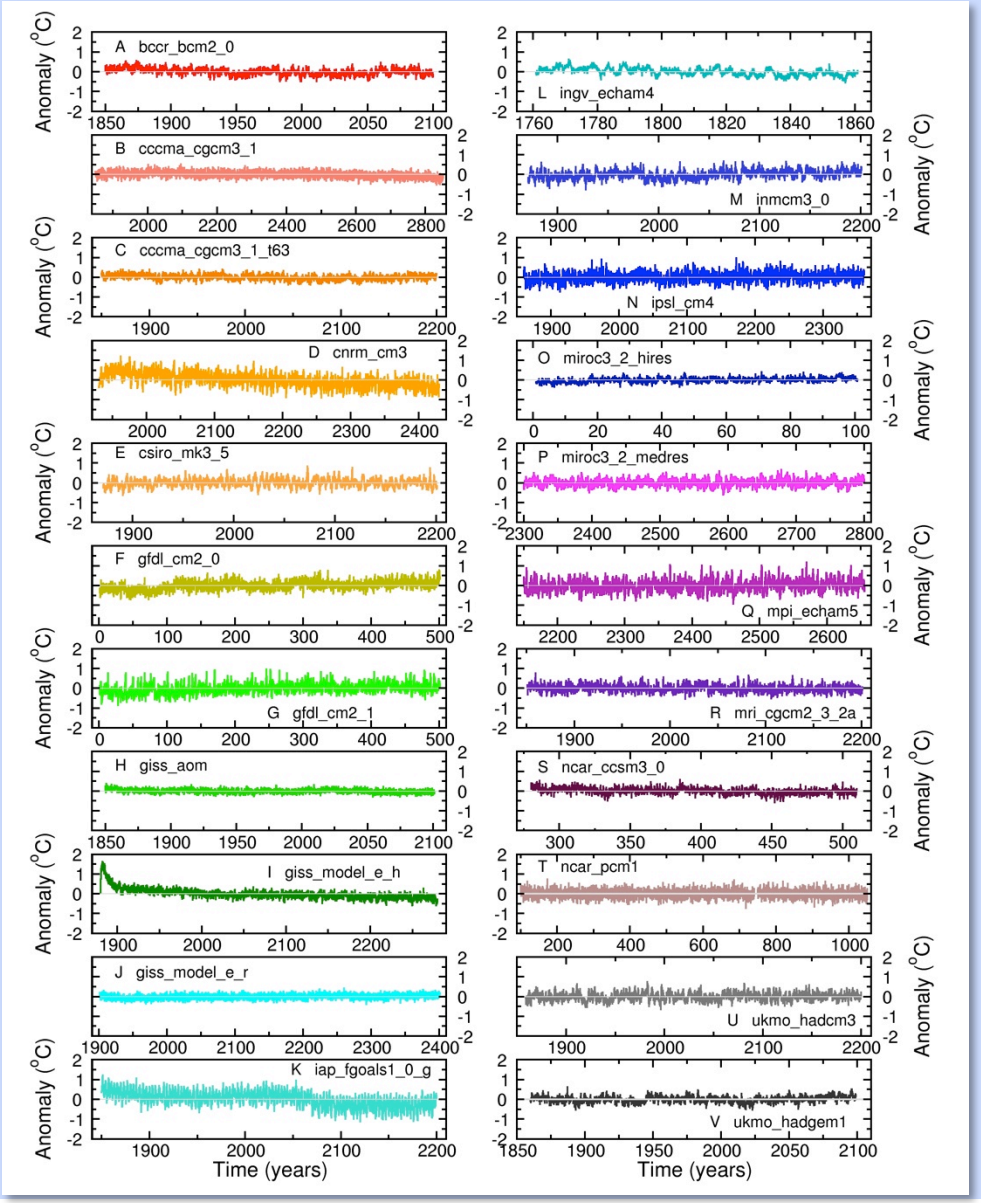
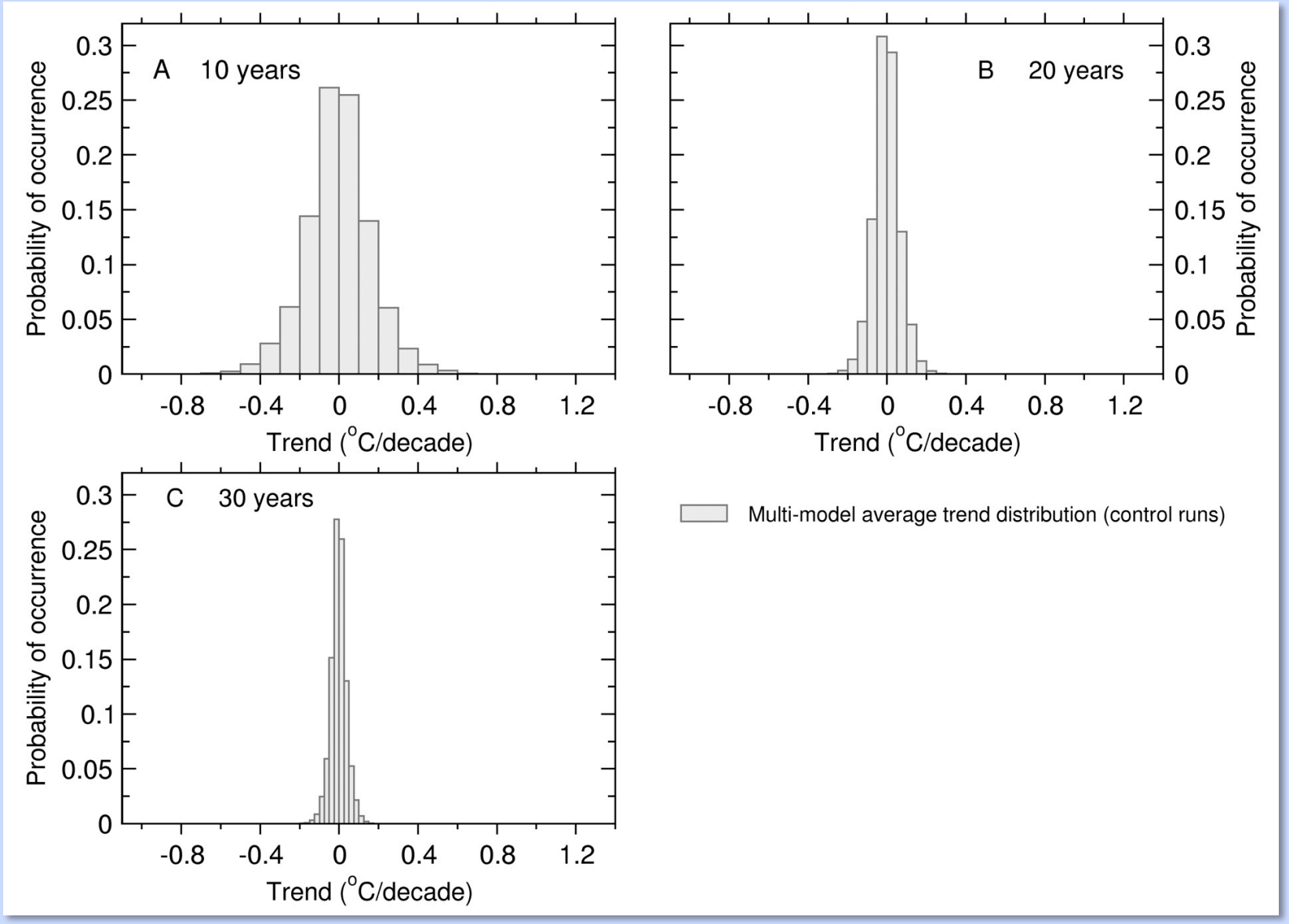


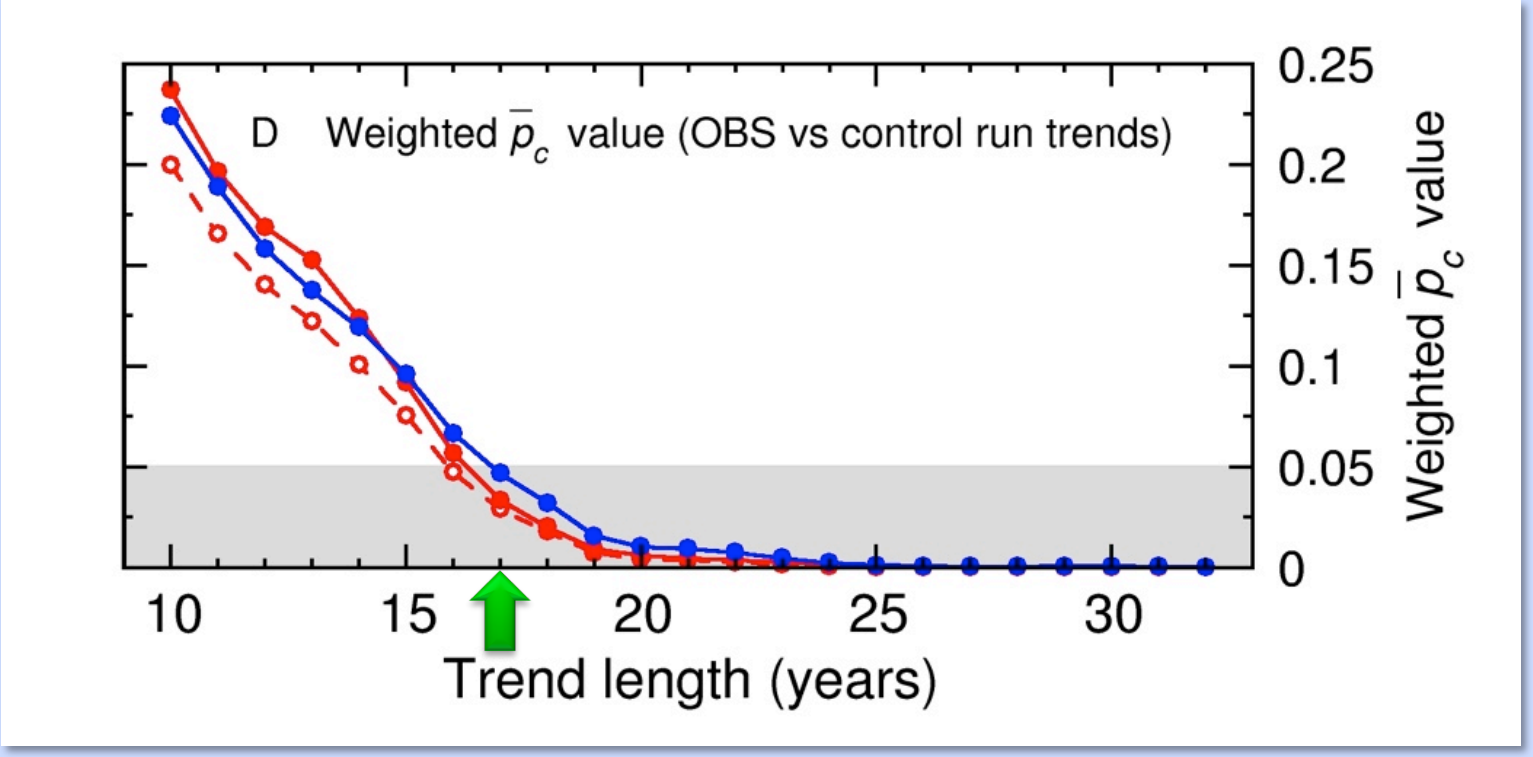
CMIP-3 simulations of natural internal TLT variability in pre-industrial control runs



Calculating CMIP-3 multi-model sampling distributions of unforced trends



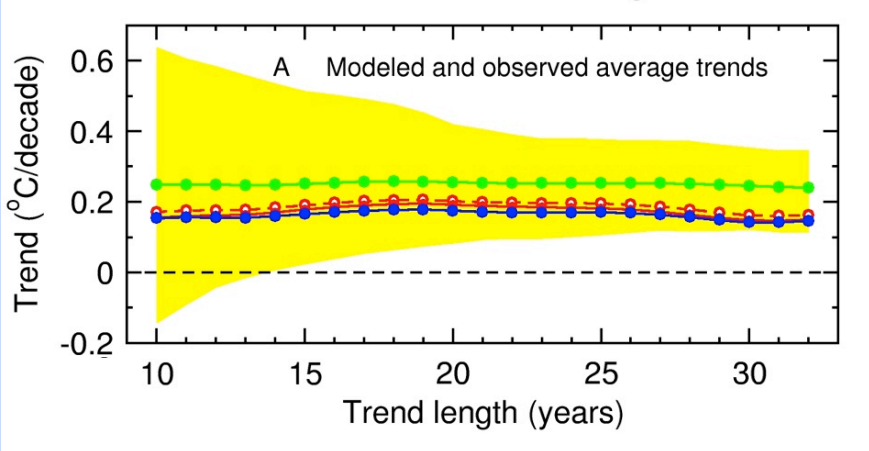
At what trend length (timescale) are observed trends large relative to CMIP-3 unforced trends?



$$P_c(i) = K_c(i) \;/\; N_c$$

$K_c(i)$ = Number of L-month trends in MMSD of control run trends that are larger than $b_o(i)$ (the current L-month observed trend)

Putting it all together: Estimating S/N ratios as a function of timescale



Observations (RSS v3.2)
Observations (RSS v3.3)
Observations (UAH)
Multi-model average
5-95 percentiles (MMSD of 20CEN/A1B trends)

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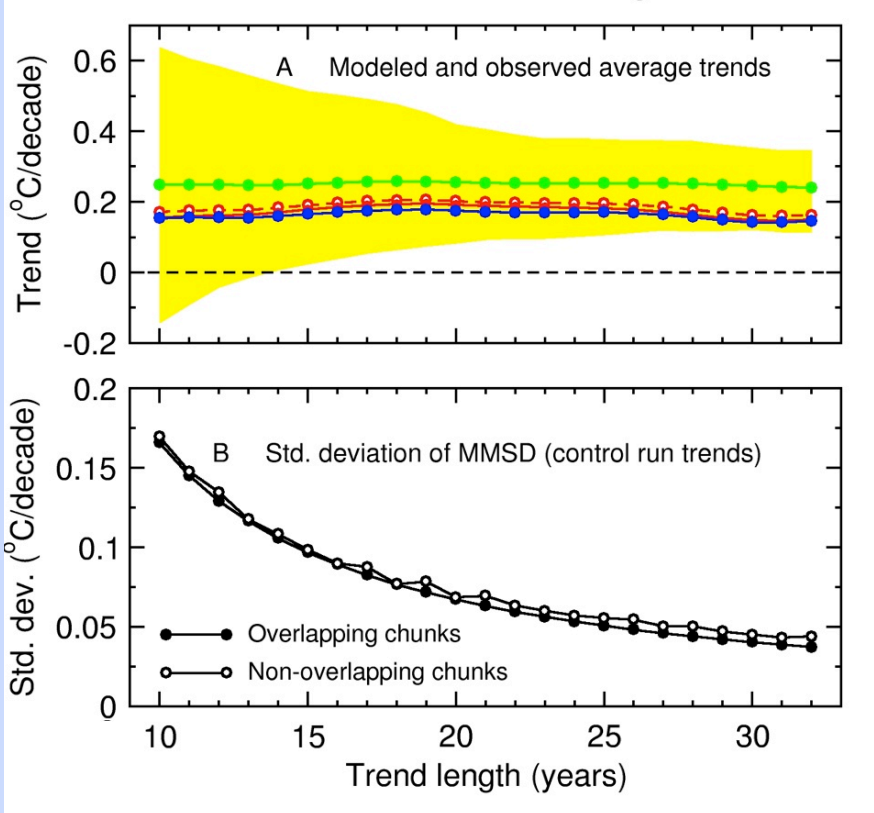

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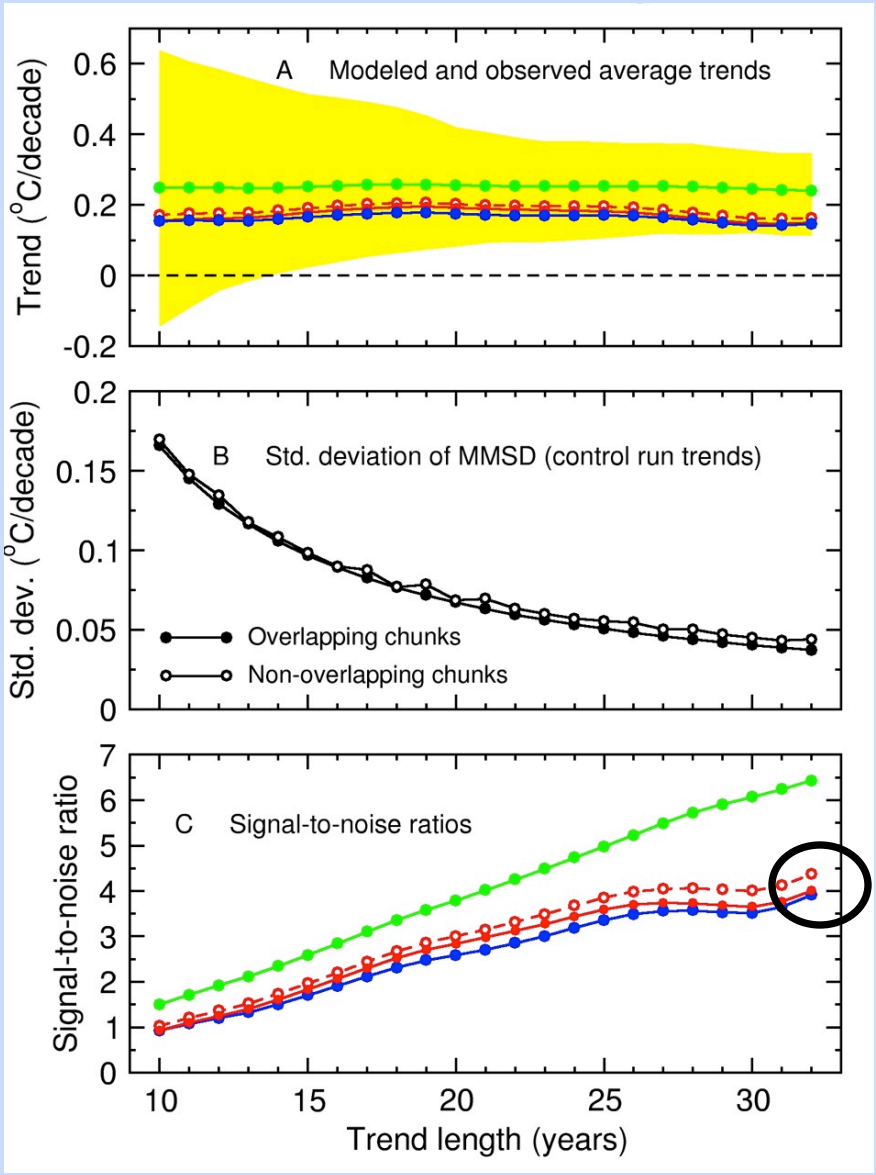

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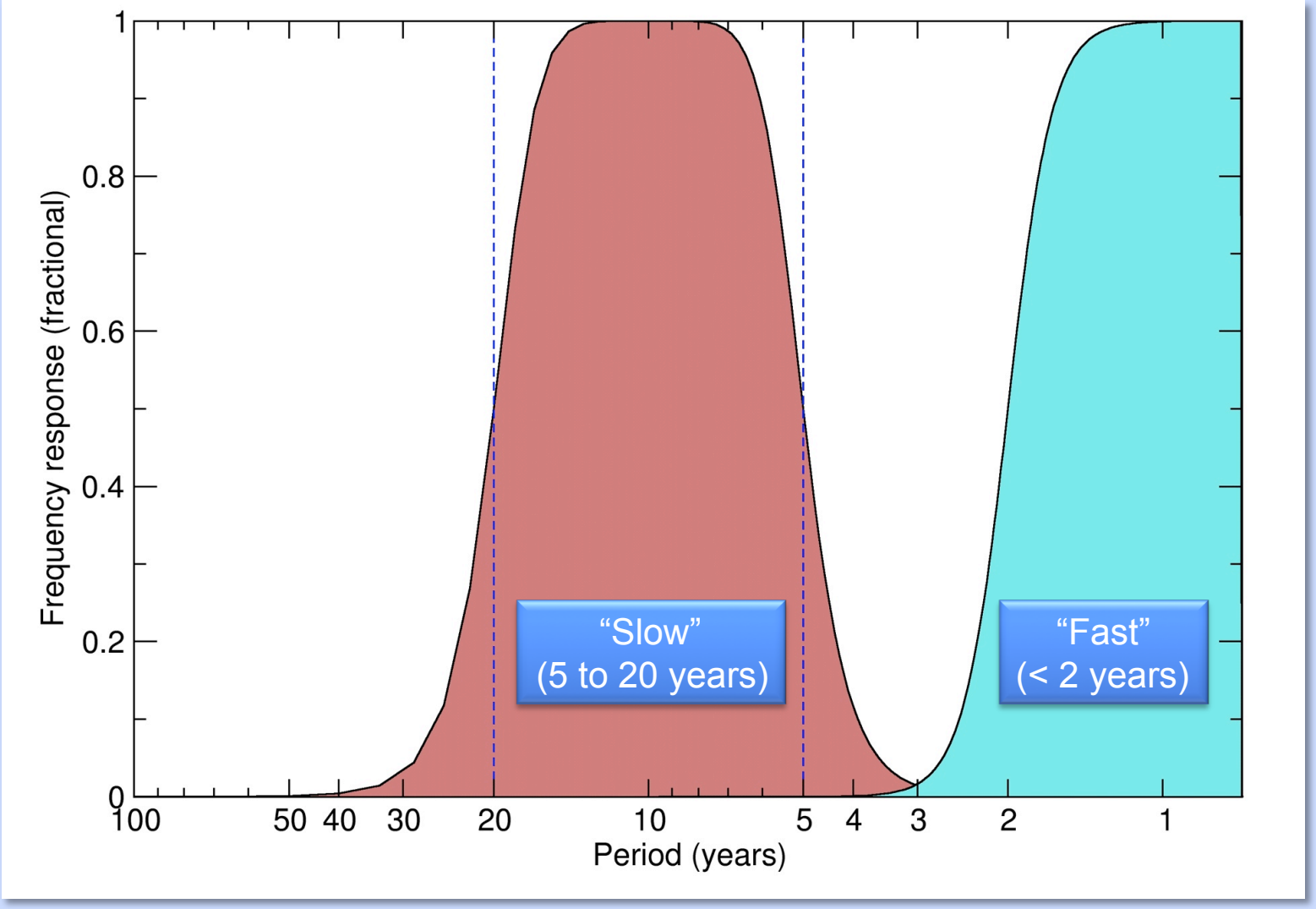
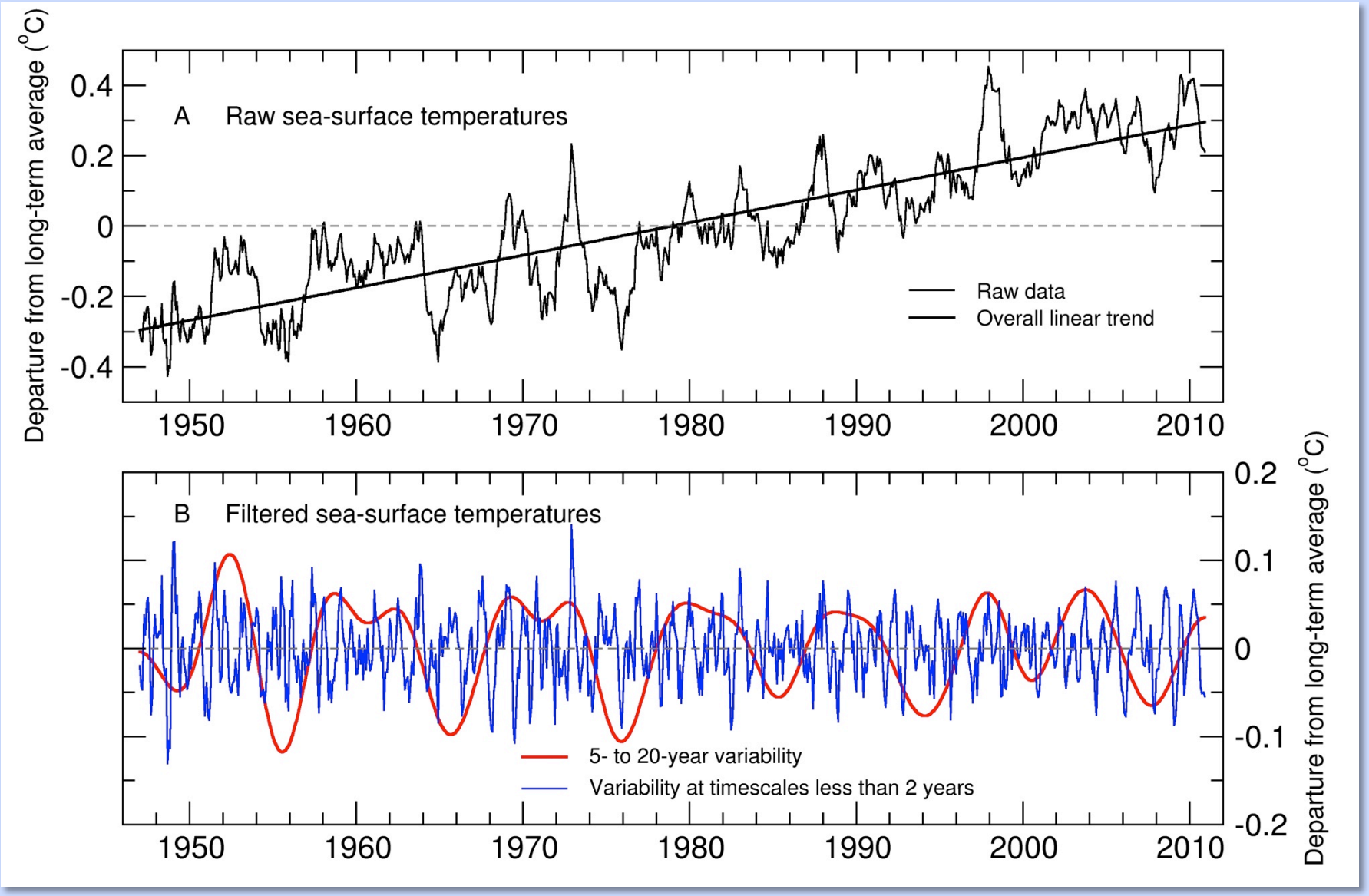
Multi-model average

5-95 percentiles (MMSD of 20CEN/A1B trends)

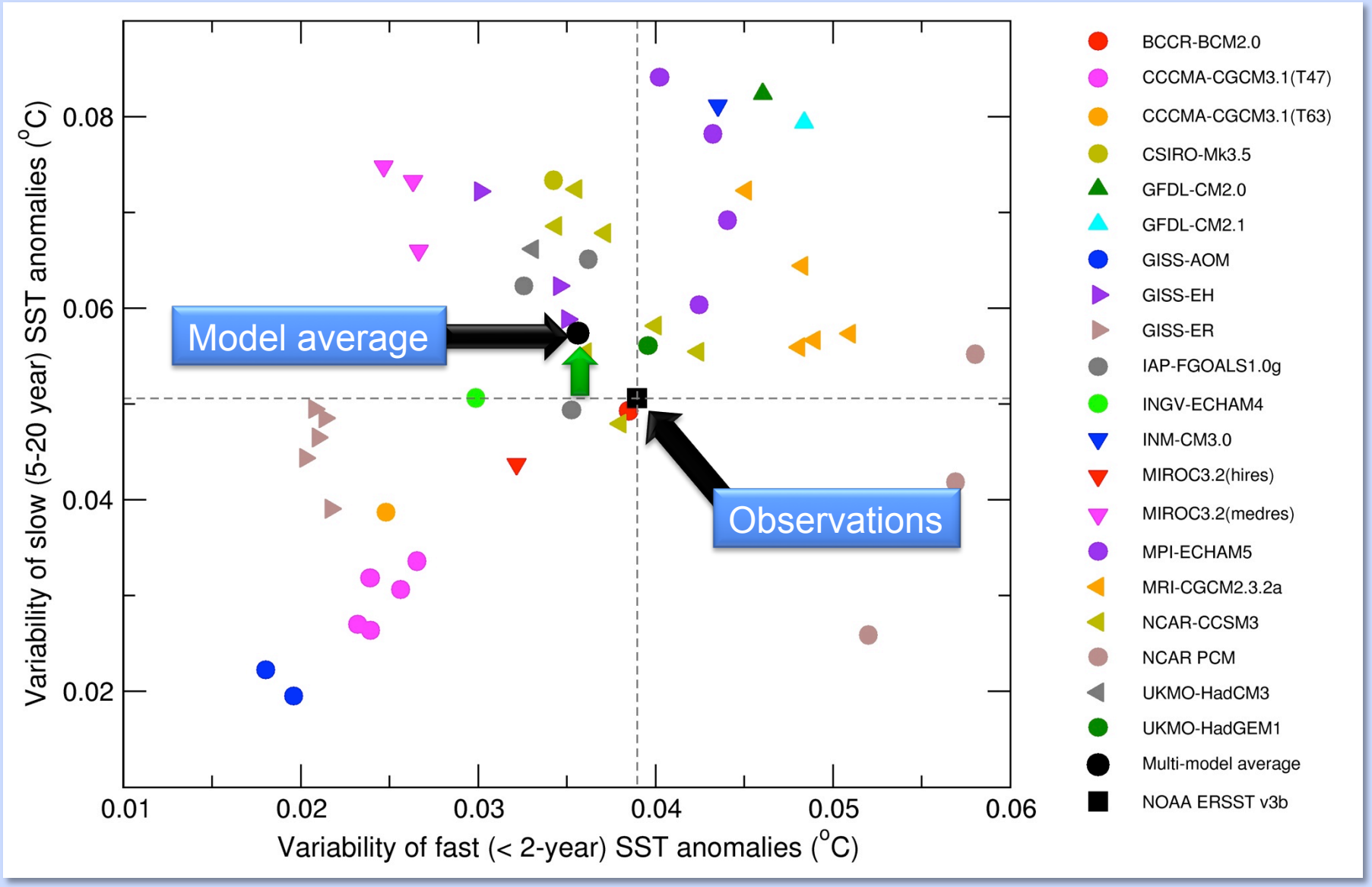
Are the estimated S/N ratios too large on multidecadal timescales?



Band-pass filtering of SST data



On average, model "slow" sea-surface temperature variability is slightly *larger* than in observations



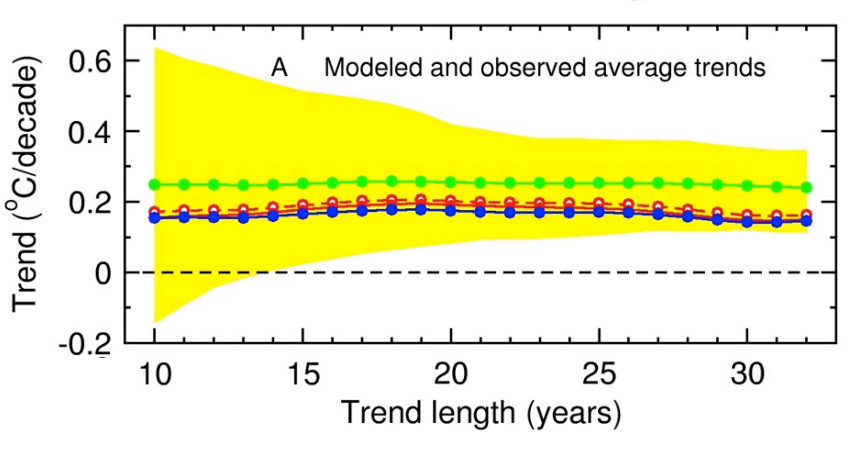
Fact or fiction? Models overestimate observed lower tropospheric warming by a factor of three

- "In an interesting result, the new underlying trend remains a modest +0.09°C/ decade for the global tropospheric temperature, which is still only one third of the average rate the climate models project for the current era (+0.26°C/decade)."
- "This evidence strongly suggests that climate model simulations on average are simply too sensitive to increasing greenhouse gases and thus overstate the warming of the climate system".*

*Professor John Christy, the University of Alabama at Huntsville

Testimony before U.S. House of Representatives Subcommittee on Energy and Power, Committee on Energy and Commerce, March 8, 2011

Are model trends in global-mean lower tropospheric temperature three times larger than observed?



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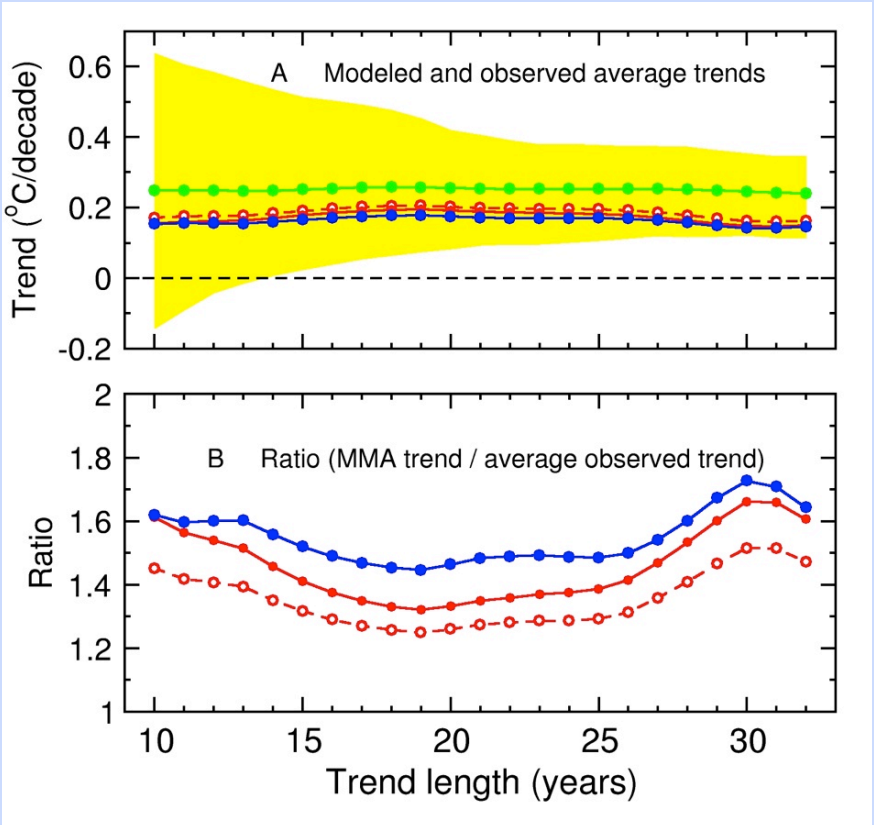
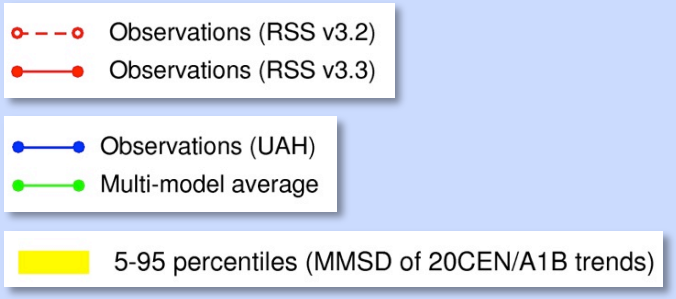




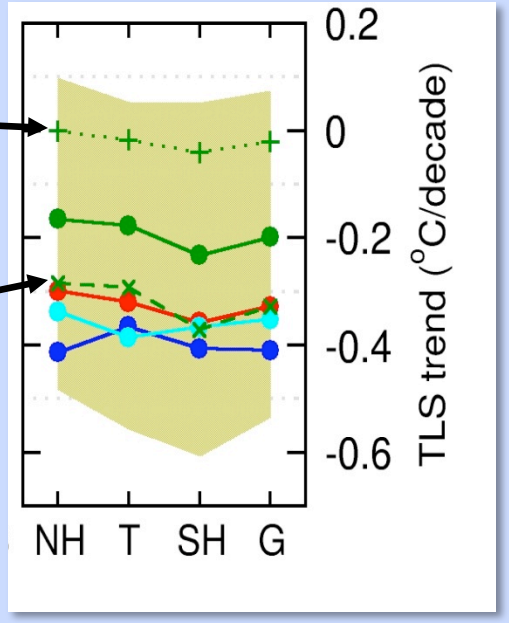
Possible explanations for warming bias in model TLT trends

- Model response errors
- Residual errors in observations
- Neglect and/or inaccurate representation of key negative anthropogenic forcings in many of the CMIP-3 simulations of forced climate change
  - Stratospheric ozone depletion, indirect aerosol effects
- Omission of recent temporal changes in solar and volcanic forcing
- Forcing discontinuities at the "splice points" between CMIP-3 simulations of 20th and 21st century climate change
- An unusual manifestation of natural variability in the observations

1. Neglect/inaccurate representation of key negative external forcings

Models without ozone depletion

Models with ozone depletion



Observations (Santa Rosa group)

Observations (University of Alabama at Huntsville)

Observations (NOAA/NESDIS group)

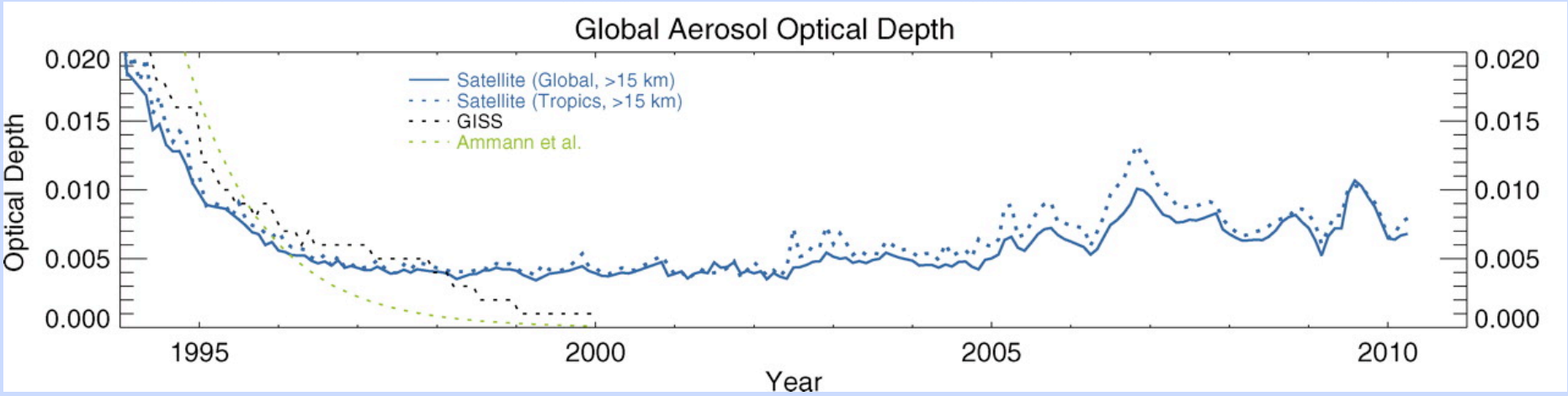
Multi-model average (all models)

Multi-model average (models with O_3 depletion)

Multi-model average (models without O_3 depletion)

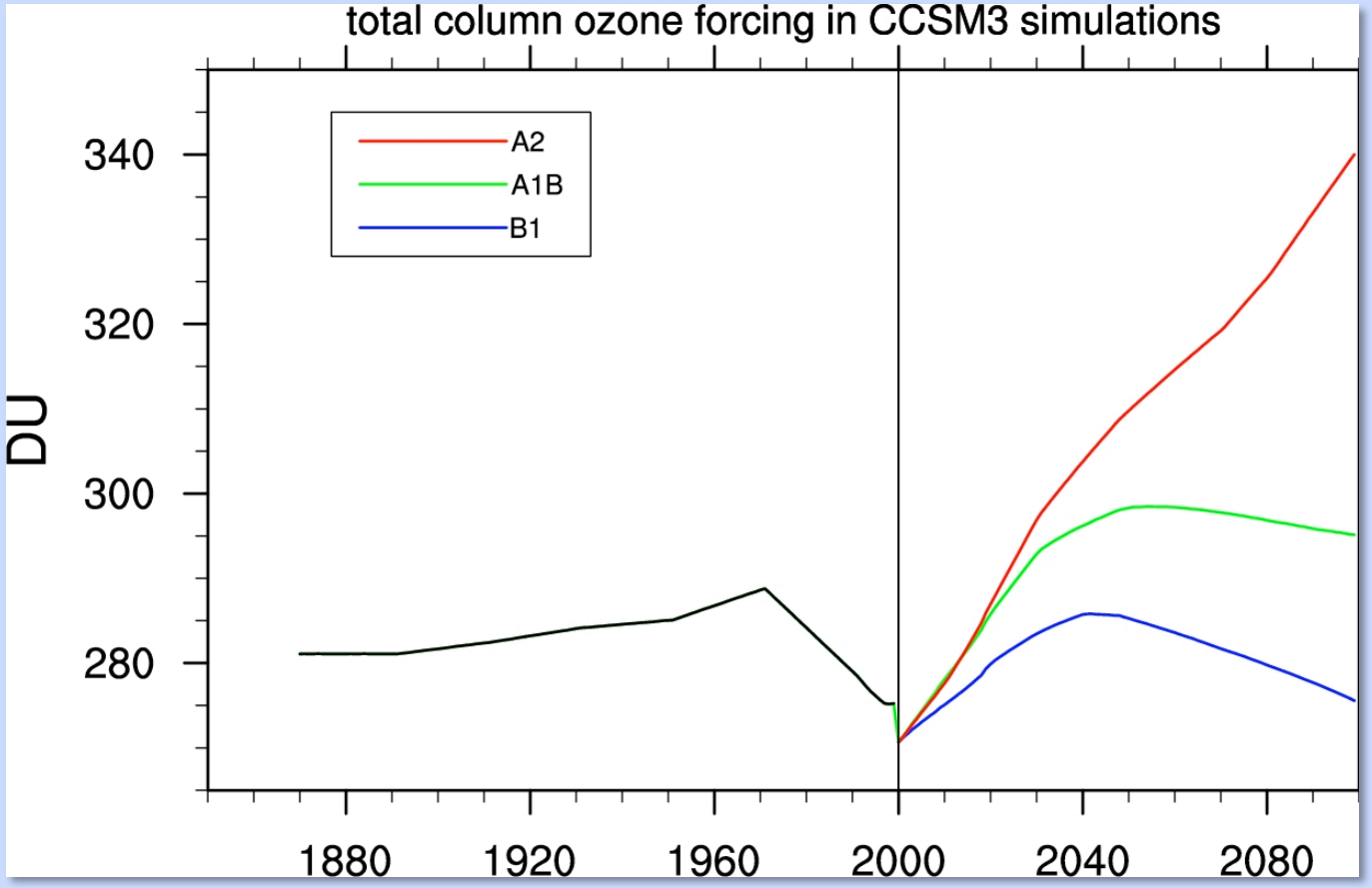
5-95 percentile, multi-model sampling distribution of forced trends

2: Omission of recent changes in solar and volcanic forcing



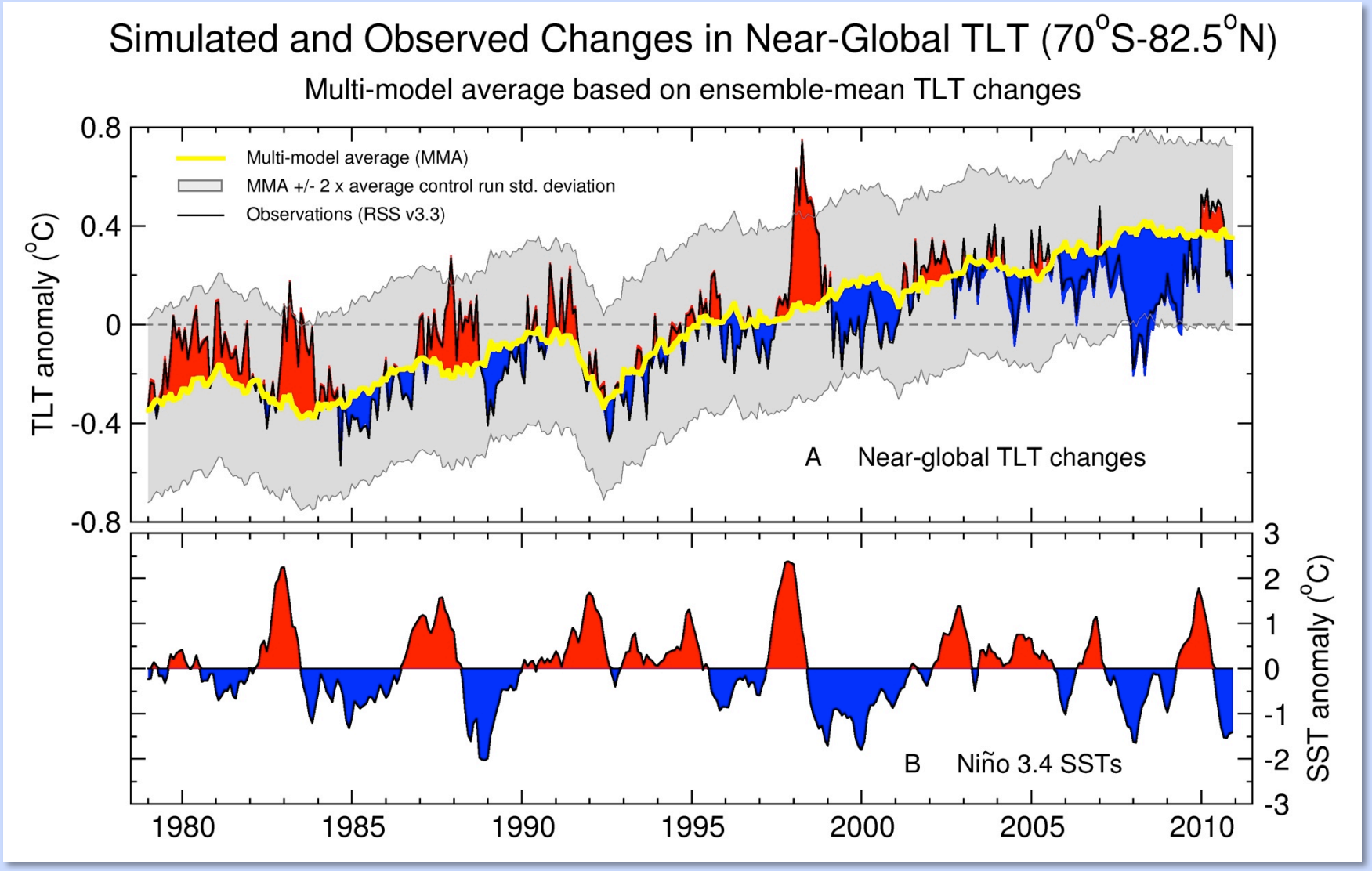
Solomon *et al.*, Science (2011)

3: Forcing discontinuities at “splice points” between 20CEN and A1B runs



Courtesy of Julie Arblaster

4. An unusual manifestation of natural internal variability in the observations



Conclusions

- Even when run with human-caused changes in greenhouse gases and aerosols, climate models can simulate 10-year periods with minimal warming of the lower troposphere
  - Claims to the contrary are demonstrably incorrect
- TLT records must be at least 17 years long in order to discriminate between internal climate "noise" and the "signal" of human-caused changes in atmospheric composition
- The S/N ratio for the global-scale TLT increase over 1979 to 2010 is ≥ 4
  - The lower tropospheric warming signal over the last 32 years is at least four times larger than model estimates of climate noise on the 32-year timescale
  - We found no evidence that the CMIP-3 models systematically underestimate the amplitude of observed SST or TLT variability on decadal timescales
  - Natural internal variability is highly unlikely to explain the observed TLT trend